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HINTS

REGARDING

THE MANAGEMENT AND USE OF X-RAY APPARATUS.

By Lieutenant and Quartermaster F. BRUCE,
Royal Army Medical Corps.

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PREFACE.

THE want of a short, simple and practical manual on the subject of X-rays, for the use of officers and men under instruction at the Royal Army Medical College, has long been felt. Most of the works on the subject are too bulky and elaborate, and describe methods and apparatus little suited to Service requirements. The following chapters, reprinted from the "Journal of the Royal Army Medical Corps," will, it is hoped, supply the need, and prove useful to those for whom they have been written. The author has had great experience, and the methods he recommends produce, in his hands, results that can hardly be surpassed.

C. G. S.

December 17th, 1906.

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CHAPTER I.

In presenting to the readers of the "Journal" the first of a series of papers dealing with this subject, I desire to point out that it will be treated entirely from a practical standpoint. The published works dealing with the practice of skiagraphy, although excellent in their way, are too much burdened with theoretical matter to be of any real assistance to the average aspirant. It is not altogether necessary to understand the technicalities affecting the manufacture of the instruments. Makers having a reputation to maintain are not likely to supply apparatus which will not stand the test for efficiency. The X-ray worker should simply endeavour to understand the functions of each component part and thus be able, not only to manipulate the instrument as a whole in an intelligent and methodical manner, but at the same time to locate a fault wherever situated. It is advisable, although not indispensable, to have an elementary knowledge of electricity before commencing the study of skiagraphy. The X-ray worker only needs to know the meaning and application of a few of the principal electrical terms, and these will be explained in the text where necessary. With these few remarks as a preface, I will now endeavour to explain the different parts of the apparatus, avoiding technicalities as much as possible, and lastly, how a skiagraph may be taken.

Electrical Supply.—The electrical supply may be either direct or indirect. Direct, when the instrument is connected with a dynamo or public main; indirect, when accumulators are charged from either of these, and afterwards used to supply the necessary current to the apparatus. In the direct method the voltage is too high and must be brought down. Before deciding, however, on this means of supply, it must first be ascertained whether the current is continuous or alternating, as the latter requires a rectifier or transformer. Being satisfied in this particular, the services of an electrician should be obtained to arrange for the necessary current and connections. When a continuous current is available the

strength and volume are modified by means of ordinary incandescent lamps placed in circuit. The electrician should be informed regarding the amount of volts and ampères required, and he will arrange the necessary number of lamps. If the current is required for a 10-inch coil having a platinum interrupter, 18 volts with five ampères will usually be ample. For the same size of coil, but fitted with a mercury interrupter, at least 32 volts with five ampères will be necessary. In either case the lamp resistance should be adjustable, that is to say, it should be possible to increase or diminish at will the number of lamps; the reason being that, as each lamp allows a certain quantity of current to pass, the supply will be under control.

Use of Continuous Current from Mains.—Another method of utilizing a continuous current from the mains is to make use of a shunt resistance. This contrivance can be seen at the Royal Army Medical College, and I am informed does its work satisfactorily. Like the lamp resistance, the services of an electrician are necessary to arrange the connections, as amateur tampering with mains may lead to dangerous consequences, involving perhaps loss of life to the person who may have the temerity to attempt work in performing which electricians occasionally suffer injury.

Accumulator Cells.—The indirect supply falls under this heading, and as it is the most generally used, a full description of these cells will appeal to the needs of the average operator. An accumulator cell differs from a primary cell in that its action is the result of current obtained from a dynamo, whereas the action in the latter is originated in the cell by electrolysis. The enumeration of the parts comprising an accumulator cell will, it is hoped, be of some little assistance to the uninitiated.

Case.—Made of teakwood and varnished.

Cells.—Usually made of vulcanite, on account of its non-conducting properties, which provide against leakage of electricity from the cell.

Plates.—These are made of lead, as free from impurities as possible. On their surfaces are cast numerous small holes in which to contain a paste containing red lead for the positive and yellow lead or precipitated metallic lead for the negative plates. There is always an odd number of plates in a cell, the positives being in the minority. These being placed side by side in the cell both sides of the positives will be faced by negatives.

Separators.—These are made from strips of vulcanite, and are placed between the plates to prevent contact, and also between plates and sides of cells to give firmness to the section.

Connections.—These are strips of lead and serve the purpose of joining all the positive plates of one cell to all the negative plates in adjoining cell, when the cells are coupled in series.

Electrolyte.—This is the medium by which the current passes from plate to plate, and is composed of sulphuric acid and water. The specific gravity of this solution is 1·2 when the cell is fully charged.

In preparing this solution the sulphuric acid used must be free from impurities, such as *arsenic*, *nitric* or *hydrochloric acid*. The acid should be gradually added to the water, which must be pure, until the hydrometer shows a specific gravity of 1·190 when cold. The electrolyte must not on any account be put into new cells till all is ready for charging.

Terminals.—Two brass terminals are fitted to each cell to connect it with an apparatus. The positives are marked + and the negatives −. The former are painted red and the latter black.

Arrangement of Cells.—In batteries containing two or more cells the positive plates in one cell are coupled to the negative plates in an adjoining cell. This arrangement is termed coupling up in series. For example, if the voltage of one cell is two volts, then that of a six-cell battery would be 12 volts. In cases where much current (amperage) is required at a low pressure or voltage, all the positive plates in the cells of a battery are coupled together to form one pole or terminal, and all the negative plates coupled in like manner to form the other pole or terminal. It converts the six cells into one large cell. The voltage, however, is that of one cell, hence the amperage is increased at the expense of the voltage.

To briefly illustrate the above examples of batteries coupled in series and in parallel, the following will show by comparison how the volts and ampères are affected by the different arrangements.

	Volts.	Ampères.
Six-cell battery in series	12	35
„ „ parallel	2	210

Capacity of a Cell.—By this is meant the number of hours a given cell will supply an instrument absorbing one ampère of current; in other words, the number of ampère-hours a cell

contains. Approximately a square foot of positive plate (not surface) should give 100 ampère-hours.

Voltage (Electro-motive Force).—The voltage of a cell should be 2·5 volts when fully charged, but this pressure quickly falls to 2·2 volts and remains at this until exhausted, when it rapidly sinks.

Action in the Cell during Process of Charging.—Before the current from the dynamo is switched on, the condition of the plates and electrolyte is as follows :—

Positive Plates.		Electrolyte.		Negative Plates.
$PbSO_4$	....	$H_2SO_4 + H_2O$	....	PbO

When the current from the dynamo is passed through the cell a series of changes takes place in the plates and electrolyte, molecules of water are removed from the latter and an equal number of molecules of H_2SO_4 added, thus increasing the strength of the solution. The following will convey a general idea of what takes place :—

Positive Plates.		Electrolyte.		Negative Plates.
PbO	....	$H_2SO_4 + H_2O$	....	PbO

When the cells are fully charged the condition of the plates and electrolyte will be :—

Positive Plates.		Electrolyte.		Negative Plates.
PbO_2	....	$H_2SO_4 + H_2O$	....	Pb

Indications showing that a Cell is Fully Charged.—(1) By means of a voltmeter each cell should give at least 2·2 volts. (2) The specific gravity of the electrolyte should be 1·2.

Care of Cells.—As the care of cells is by no means the least important item, a few essential points are given in detail regarding their management.

(1) *Rate of Discharge.*—The number of ampères taken from a cell at one time must never exceed the amount as stated by the makers. If exceeded, a strain is put on the plates which they are not made to withstand.

(2) The practice of trying the strength of a cell by connecting the terminals by a piece of wire cannot too strongly be condemned. It short-circuits the plates, and will cause irreparable damage.

(3) Accumulator cells should be kept in as even a temperature as possible, as they are very sensitive to atmospheric variations. This is often the cause of otherwise unaccountable leakage.

(4) Batteries should preferably be placed on glass blocks to prevent any possibility of leakage occurring through the medium of moisture either from a damp floor or solution percolating through the casing from the cell.

(5) The level of the electrolyte should be kept at least a quarter of an inch above the tops of the plates.

(6) When cells are being moved from place to place they must be kept as level as possible to avoid spilling the electrolyte. They must also be carefully carried, as knocking and jarring might possibly damage the plates.

(7) The terminals must be kept clean, as dirty contacts act as a resistance, and therefore a needless loss of energy.

(8) The interiors of the cells require to be frequently examined for the purpose of ascertaining if the junctions are in good condition, and the solution is at the proper level. The colour of the solution should also be noted, because if dirty, something is wrong with the plates. Sulphating should be looked for in order that this evil may be checked in its earliest stages.

(9) The efficiency and life of a cell depend in a great measure on the way the charging and recharging have been carried out. Unfortunately we are in the hands of the people owning the charging plant, and damage to plates might be originated through carelessness in charging, which may not become manifest for some time afterwards, hence the instructions given in No. 8 should be carefully carried out.

(10) Cells must on no account be worked when the voltage has fallen below two per cell. To keep them in good order they should be sent to the charging station at least once a fortnight, whether they have been worked or not. This system will assist in keeping down sulphating to a considerable extent.

If the foregoing instructions are carefully carried out the evils inherent in accumulator cells will be greatly minimised, if not entirely obviated.

Buckling.—The buckling of a plate infers that it has become bent from some cause, and whilst in this condition there is danger from the paste falling down and not only causing a loss of active surface but by pieces sticking between the plates and short-circuiting the cell. These should be carefully removed, and the cell sent to an electrician for repair, as only

skilled workmen are capable of putting matters right. Buckling may be caused by exceeding the discharge as laid down by the makers. It may also be caused by knocking or jarring the cell.

Sulphating.—This is generally the result of overworking the cell, and is known by a white sulphate forming all over the plates; when it appears the addition of a solution of caustic soda to the electrolyte, together with a prolonged recharging, will assist in checking its further progress.

Wires from Battery to Coil.—These should be at least B.W.G. No. 14, in order that the current may not suffer any resistance in passing. They should be well insulated to avoid leakage.

Switch.—An appliance placed in circuit for turning on and off the current.

Rheostat.—A variable resistance placed in circuit for controlling the current.

Cut Out.—An appliance made of stoneware, and placed in the main circuit. In it is fixed a piece of lead wire calculated to carry any desired amount of current; when this current is by any chance exceeded, the wire offering a resistance to its passage melts and breaks the circuit.

Ammeter.—An instrument for recording the number of ampères passing in a main circuit.

Voltmeter.—Used for measuring the voltage of a cell. It is never placed in the main circuit on account of the resistance it offers to the passage of a current.

CHAPTER II.

The Induction Coil.

When we learn that a pressure of 50,000 volts is necessary in order to spark across one inch of air, it is obvious that the voltage obtained from a set of accumulator cells is useless for the purpose of exciting a vacuum tube in which the terminals are a few inches apart. By the aid, however, of the induction coil, the voltage is raised to suit our requirements. This instrument consists of the following parts, and as it is necessary that they should be well understood, they are described at some length.

(1) *Core.*—Composed of a bundle of very soft iron wire, the pieces being the same length as the finished coil. The core is immersed in melted paraffin wax, and afterwards wrapped from end to end with a layer of paraffined tape. When the coil is acting the magnetisation of the core furnishes the magnetic field to produce the phenomenon of induction in the secondary coil.

(2) *Primary Coil.*—This is formed by three layers of insulated copper wire, No. 12 B.W.G., wound round the core, and the whole immersed in melted paraffin wax. The ends of the wire forming the coil are continued through the interrupter, to the terminals marked "Battery" on the baseboard. The object of the primary coil is to magnetise the core when the current is passing.

(3) *Insulating Tube.*—Made of ebonite, and contains the primary coil and core. Its object is to separate the primary from the secondary coil between which there is a great tendency to spark.

(4) *Secondary Coil.*—Over the insulating tube on the primary coil is wound in layers and sections several miles of No. 36 silk-covered copper wire embedded in wax. This forms the secondary coil. When the magnetic field is formed by the magnetisation of the core, an induced current is produced in the secondary coil of very high electro-motive force.

(5) *Condenser.*—The condenser consists of a number of layers of thin tin-foil, insulated by layers of paraffined paper, alternate layers of the tin-foil being connected together, thus forming really two large sheets of foil, one of which is connected to the pillar holding the contact spring of the contact-breaker, and the other to the pillar carrying the contact screw. The condenser is thus a bridge across the "make" and "break." It therefore destroys the detrimental self-induction of the primary coil, allowing the primary current to rise and fall at once, to and from its full strength. The self-induction of the primary circuit being reduced to a low point, the sparking of the contact-breaker is therefore at a minimum. It is placed in the base of the coil.

(6) *Discharging Pillars.*—These are generally placed on the top or baseboard of the coil, and are made of ebonite. Through their centres are conducted the ends of the secondary coil. These ends are secured to the brasswork fittings on the tops of the pillars. To these fittings provision is made for attaching the wires leading to the tube. There are also arranged on the brasswork fittings sliding holders, in which brass rods are fitted having ebonite handles, so that they can be manipulated with safety. The power of a coil is found by approximating or separating the points of the rod between the pillars, and the distance from point to point over which a spark can pass determines the capacity of the coil. The resistance of a tube is gauged by the alternative spark between these points.

(7) *Terminals.*—These are for attaching the wires from the battery and a mercury interrupter, and are so marked.

(8) *Commutator.*—By means of this appliance, which is fitted on the baseboard, the direction of the current can be changed as well as cut off.

Interrupters.—The phenomenon of induction in the secondary coil is only produced at the moment when the circuit in the primary coil is closed or opened. In order that the spark given off by the coil may be rich and powerful it is not only important that the interruption of the current in the primary circuit should be of great frequency, but it is also as important to be able to so adjust the action of closing the circuit that its effect on the core, by magnetic saturation, will be to create an intense magnetic field round the secondary coil. The object of an interrupter is to effect that end.

There are three kinds of interrupters, viz., the platinum,

the mercury, and the electrolytic. As their mode of action differs very considerably, separate descriptions are necessary so that the advantages and disadvantages incidental to each might be compared.

Platinum Interrupter.—This interrupter is actuated in two ways. Firstly, by taking advantage of the magnetic properties in the core, and secondly, by an electro-magnet when it is constructed separate from the coil, as in Apps' portable apparatus. The principle, however, is the same in both.

Before proceeding further, it is necessary to understand that the term "make" refers to the magnetisation of the core, and the "break" when the current is interrupted.

The action of a platinum interrupter can be best understood by referring to Fig. 1. At the "make" the current entering

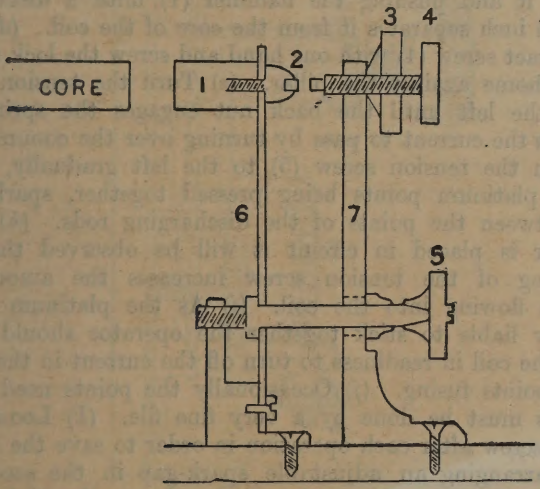

FIG. 1.

from the positive pole of the battery ascends the brass pillar (7), passes through the platinum points (2), down the spring (6), and then on to primary coil, where, on passing, it magnetises the core and attracts the soft iron hammer (1). The hammer on being pulled away from its normal position separates the platinum points, breaking the circuit as there is now no direct path for the current to flow. The current having ceased at the separation of the platinum points to pass through the primary coil, the soft iron core immediately

becomes demagnetised and releases the hammer, bringing the points together, when the "make" is again made, and so the "makes" and "breaks" succeed each other automatically until the battery current is cut off by the commutator. As an inverse current is produced at the "make" and direct at the "break," it is obvious that the current in the secondary circuit is alternating. The impulse, however, of the direct current being much more powerful than that of the indirect, owing to the action of the condenser, the effect produced by the latter is almost imperceptible.

In adjusting a platinum interrupter, the following instructions should be carefully carried out, viz., (*a*) Turn the tension screw (5) to the right until the spring (6) swings freely. (*b*) Loosen the lock nut (3). (*c*) Adjust contact screw (4) by turning it and pushing the hammer (1) until a distance of $\frac{1}{32}$ of an inch separates it from the core of the coil. (*d*) Hold the contact screw (4) with one hand and screw the lock nut (3) tightly home against the pillar. (*e*) Turn the tension screw (5) to the left until the back nut engages the spring (6). (*f*) Allow the current to pass by turning over the commutator. (*g*) Turn the tension screw (5) to the left gradually, when, on the platinum points being pressed together, sparks will pass between the points of the discharging rods. (*h*) If an ammeter is placed in circuit it will be observed that the tightening of the tension screw increases the amount of ampères flowing into the coil. (*i*) As the platinum points are very liable to stick together the operator should stand beside the coil in readiness to turn off the current in the event of the points fusing. (*j*) Occasionally the points need filing, and this must be done by a very fine file. (*k*) Loosen the tension screw after each operation in order to save the spring. (*l*) By arranging an adjustable spark-gap in the secondary circuit the liability of the points to fuse is greatly minimised.

This type of interrupter, although still supplied by makers on most of their coils, is now very seldom used, as in comparison with the newer types it signally fails to produce the maximum effect of a coil.

Mr. Cox has lately introduced an improved form of platinum interrupter, having distinct advantages over the one just described. With a 12-volt current it gives more excellent results than can be obtained by the old pattern with 18 volts. In addition, the waste in platinum is not nearly so great, and

the adjustments, when once arrived at, need practically no further attention. For field service work it will be much appreciated on account of the small voltage required. This is a great consideration, as batteries are difficult to maintain on active service, and any improvement which will reduce the numbers required will be welcomed by the X-ray operators. As this form of interrupter is likely to be extensively used in the future, a full description of its adjustment will not be out of place. On reference to Fig. 2 it will be seen that there

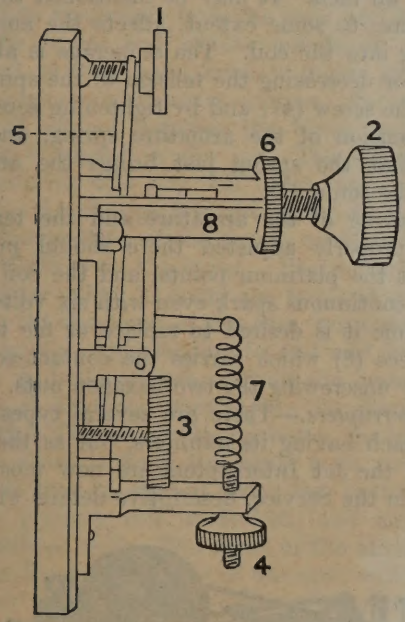

Fig. 2.

are four screws provided to adjust the action, viz., 1, 2, 3 and 4. The amount of play between the platinum points is regulated by the contact screw (2). The more this screw is withdrawn the larger will be the gap between the platinum points at the time when the inner point is drawn back through the armature (5) being attracted to the core.

When working with 12 volts on the coil push the armature (5) as far back as possible and so separate the platinum points.

Then adjust the contact screw (2) so that the points are $\frac{1}{20}$ of an inch apart and fix by tightening the locking screw (6).

If working with six volts this distance must be slightly decreased. On increasing the voltage the distance between the points must also be increased to prevent arcing.

For lower voltages the swing of the armature (5) should be as large as possible. This swing is regulated by the screw (1). As the voltage increases the swing of the armature should be decreased. When working with 12 volts the swing should be about half an inch. It may be mentioned that the swing of the armature, to some extent, affects the amount of amperage passing into the coil. The amperage is also regulated by increasing or decreasing the tension of the spiral spring (7) by means of the screw (4); and by tightening screw (3), which governs the tension of the armature spring, and should be so adjusted that the spring just brings the armature into contact with the screw (1).

When the swing of the armature and the tension of the contacts are properly adjusted there should practically be no sparking at the platinum points, and the coil should give its full-length continuous spark even with six volts.

If at any time it is desired to replace or file the platinum points, the piece (8) which carries the contact screw (2) can be removed by unscrewing the two hexagon nuts.

Mercury Interrupters.—There are several types of these to be obtained, each having its admirers, but as the Mackenzie-Davidson and the Jet Interrupters are now most commonly used, at least in the Service, descriptive details will be limited to these.

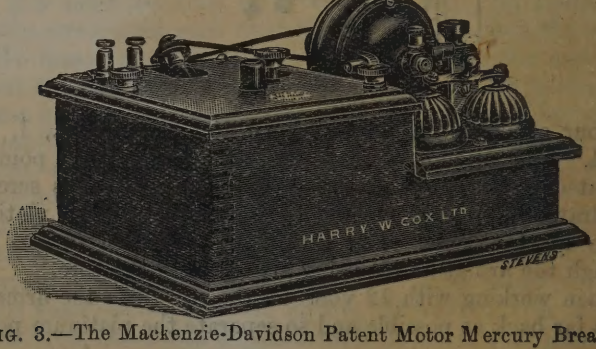

FIG. 3.—The Mackenzie-Davidson Patent Motor Mercury Break.

By the introduction of the Mackenzie-Davidson type a distinct improvement in mercury interrupters was effected. It is no doubt a most excellent instrument, and is very easily manipulated. In its action a motor rotates a spindle having a blade fixed at its lower end which makes contact by dipping in mercury. The blade is in the form of a sector, so that contact is gradually made and withdrawn. The mercury is contained in an iron jar in the case, and forms one pole. The spindle passes through the side of the jar, and revolves in an ebonite bush to insulate it from the iron, and forms the other pole. To the upper end of the spindle a grooved pulley is fitted, and to it a band from a motor arranged on the mahogany cover communicates motion. In order to adjust the degree of contact between the blade and the mercury, an iron ring is placed in the jar. The effect produced by raising or lowering this ring will be to more or less immerse the blade by the change brought about in the level of the mercury. The position of the ring is controlled by the manipulation of a screw on the cover. The motor is driven from a 12-volt battery, but 32 volts are required for the primary coil circuit. On the cover of the case, terminals are provided for connecting the wires leading to coil and battery, and are so marked. A double switch controls the motor and primary coil circuits, so that the current can be simultaneously cut off from both. This is a wise provision, as by stopping the motor alone when perhaps the blade is in contact with the mercury, the flow of current from the battery would pass through the primary coil unchecked, and not only ruin it but the battery as well. The speed of the motor is controlled by a rheostat fixed to the side of the case, and by this means the frequency of the interruptions in the primary circuit can be altered at will.

The following brief instructions are given for connecting and working this interrupter :—

(1) Remove the band which connects the motor and spindle pulleys ; (2) remove the mahogany top by unscrewing the brass thumb screws ; (3) remove the iron cover of jar by removing the screws, and note screw under which the copper spring is held in position ; (4) pour about 3 lbs., of mercury into the iron jar, and fill up to within one inch of top with pure methylated spirits. Best paraffin oil may be substituted for the spirit, but the mercury is more difficult to clean after

use; (5) screw on the iron cover, taking care that the copper spring is correctly replaced, *vide* latter part of (3); (6) replace the band on the spindle pulley; (7) replace the mahogany cover, and fix the band on both pulleys; (8) connect the terminals marked "Battery" on cover to a 12-volt battery; (9) connect the interrupter to coil by the terminals marked "Coil" on the former, and "Mercury Break" on the latter; (10) connect the terminals marked "Battery" on the coil to a 32-volt battery; (11) should the coil not be provided with special terminals for connecting with a mercury interrupter connect the pillar and spring which contain the platinum points with the terminals marked "Coil" on the interrupter. Place a piece of cork between the platinum points (because the interrupter replaces these), and wedge another piece between the hammer and end of core so as to stop vibration; (12) switch on the motor, and when it has gained a good speed switch on the coil by turning over the commutator. Should no spark pass between the points of the discharging rods, even when about two inches apart, switch off motor and coil, and add a little more mercury through the vent hole in the cover. Keep adding more mercury very gradually in small quantities until the best results are obtained; (13) the height of the mercury in the jar is regulated by the milled ebonite screw on the cover, which when turned to the right raises the ring and lowers the level of the mercury; when turned to the left the ring is lowered and the level of the mercury is raised by displacement. The ring should be at bottom of jar before the mercury is introduced in the first instance; (14) when the tube glows very weakly, and is not improved by adjustment, this is an indication that the mercury has become foul and should be cleansed; (15) in order to cleanse the mercury, remove the covers and place the jar under a tap, allowing the water to run until the mercury appears quite bright. Stirring the mercury by a piece of wood will facilitate the process.

The method of making the necessary connections is shown in Fig. 4.

Mercury Jet Interrupter.—This is a very powerful interrupter, and when properly used, is capable of securing the best effects from a coil. In addition, its ease of control places a great power in the hands of the operator, so that skiagraphing any part of the human body, from the bones in the

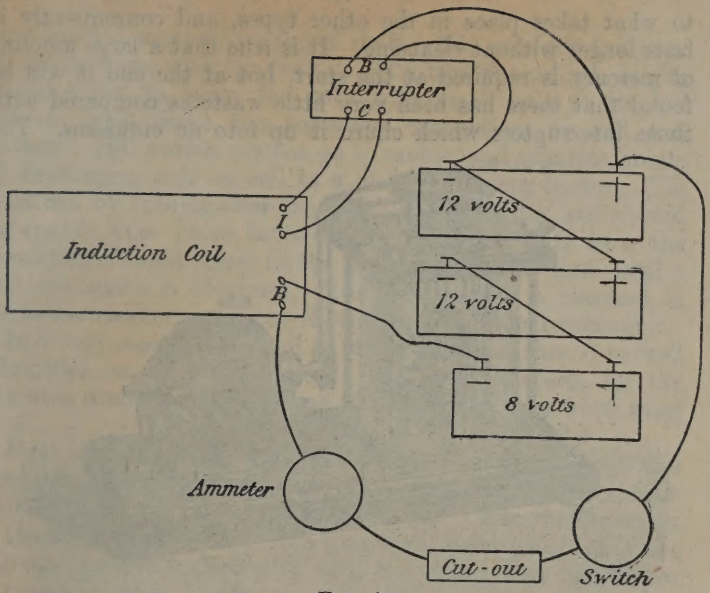

FIG. 4.

hands to those situated in the deepest tissue, is rendered easy of accomplishment by its aid. Like the Mackenzie-Davidson type a motor is provided to actuate the mechanism. This motor, which is enclosed in an iron casing, can be supplied to work from any voltage. The interruptions take place in a glass jar containing the mercury. Three graduated blades connected to a vertical shaft suspended from the cover of the jar make contact as they pass in front of a jet of mercury. By means of a pump driven at the lower end of the shaft the mercury is forced up a vertical tube. Over this tube another is fitted to slide easily up and down, and in it is pierced a small hole facing the revolving blades. These blades being triangular in shape with base uppermost, it follows that the amount of lateral surface affected by the jet depends on the position of the small hole in the tube. By means of a milled ebonite thumb-screw on the cover, the position of the hole is regulated by moving the tube up or down, thus effecting absolute control of the amount of current passing through the interrupter. There is no churning up of the mercury similar

to what takes place in the other types, and consequently it lasts longer without cleansing. It is true that a large amount of mercury is required at the start, but at the end it will be found that there has been very little waste as compared with those interrupters which churn it up into an emulsion. The

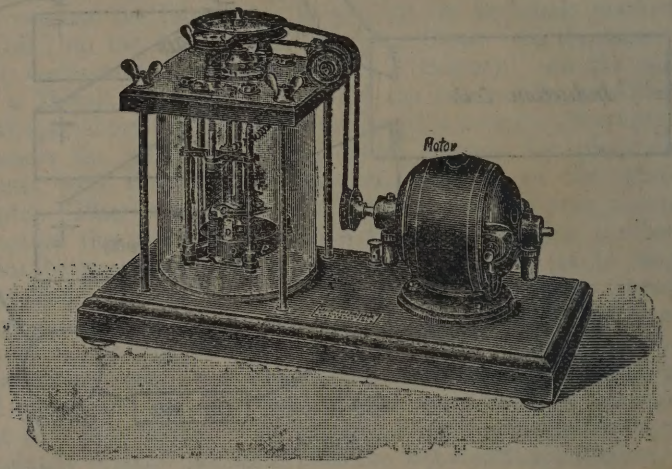

FIG. 5.—The Mercury Jet Interrupter.

Jet Interrupter is connected to coil and battery in the same manner as the Mackenzie-Davidson type. The terminals to connect with coil are placed on the cover of jar, and those to connect with battery for driving the motor are fitted to base. In preparing this interrupter for use the following procedure is recommended :—

(1) Remove the brass arm which connects the pin on cover with the cup-shaped opening on top of shaft; (2) remove the four thumbscrews to be found on corners of cover; (3) remove the band; (4) carefully remove the cover to which the internal mechanism is attached; (5) carefully wipe out the glass jar, and replace the cover; (6) replace the four corner thumb-screws, also the band; (7) by means of a funnel, pour sufficient mercury through the hole in cover to completely submerge the pump chamber; (8) fill up the jar to cover tops of blades with pure methylated spirits; (9) pour a small quantity of mercury into the cup-shaped opening on top of shaft; (10) replace the brass arm so that the point

dips into the mercury on top of shaft; (11) carefully lubricate all the bearings with the best oil; (12) turn the milled ebonite thumb-screw to lower the tube with small hole to its full extent; (13) make the necessary connections to coil and battery; (14) switch current on to motor, and separate points of discharging rods on coil to a distance of four inches; (15) start coil by turning over the commutator handle, and should no sparks take place between the separated rods turn the regulating ebonite screw to the right a little at a time until a full rich spark is obtained; (16) the mercury is cleansed in the same manner as for the Mackenzie-Davidson Interrupter.

It is very essential that all interrupter motors should be well lubricated, as they revolve at a high rate of speed, for the bearings would soon be ruined if allowed to heat from want of oil.

Motor Failures.—Provided the supply of electricity remains constant, and the bearings are well oiled, there is very little trouble to be anticipated from the motor. Often the flickering of the light in the tube is due to a slack band which does not grip the pulleys sufficiently, with the result that the motor is revolving at a higher rate of speed than the interrupter. The remedy for this is obvious. The commutator and the bearing faces of the brushes should be kept free from dirt and grease. All these will cause trouble if unattended to, and what may be only a trifling affair at first may, through inattention, develop into a serious breakdown. Should the motor suddenly cease to act, carefully examine voltage, wires, connections and brushes, and if none of these show a defect the motor should be sent to an electrician for examination, and, if need be, repair, for obviously the breakdown is serious. Failures regarding the interrupter are generally due to bad contact, resulting in an insufficient supply of current to the coil. Examine contacts, cleanse mercury, and if the motor is not out of order these will generally have the desired effect. Very often I have known interrupters absolutely unable to supply any current, and the owners quite oblivious of the fact that the mercury being so foul formed quite a resistance in itself to the passage of any current. All binding screws should be frequently examined, as the vibration of the motor causes them to work loose.

Electrolytic Interrupter.—In a glass jar containing a solution of sulphuric acid and water, a piece each of lead and

platinum are suspended from the cover to form two poles. On the cover are fixed two terminals, one from the lead and the other from the platinum. In the passage of a current from the platinum to the lead through the solution the circuit is interrupted by electrolytic action in the latter. The number of interruptions thus affected must be enormous, as the violent electrolytic action produces a shrill note. A condenser to the coil is unnecessary, probably due to the rapidity of the "makes" and "breaks" limiting the production of self-induced currents in the primary coil. The illumination of the tube is most brilliant, and the quality of the rays very effective. So powerful indeed is the intensity of the current passing through the tube that the ordinary anode would very quickly be perforated, hence tubes in which the anode is connected to a water chamber have been devised for use with this interrupter. Although ordinary coils can be made to give increased output with an electrolytic interrupter, yet those specially wound give the best results. The specific gravity of the solution should be 1·2; and it should be possible to regulate the adjustment by exposing more or less of the platinum in the jar to the electrolytic action produced in the solution by the current. In connecting an electrolytic interrupter with a coil, it is placed in series with coil and battery, and when once connected the current cannot be reversed, as the platinum in the jar must always be positive. The voltage required is greater than for other interrupters, being at least 50 volts for a 10-inch coil. This interrupter is largely used on the continent, where it finds much favour. For screen work it is excellent on account of the steady light.

Tube Holders.—These are of various patterns, but can be divided for description into two classes, viz., stand and telescope.

Stand.—The short pattern is intended for use on a table, and the long to stand on the floor, and is very useful when taking a skiagraph of a patient in bed. All are of much the same construction, and consist of a weighted base to give steadiness, and an upright on which is secured an arm to hold the tube.

Telescopic.—This pattern can be fixed to a table top, and is very portable. It consists of a series of tube lengths, each supplied with a binding screw, and fitting into each other like the draws of a telescope. The lower length is attached to a

clamp for fixing to the top edge of a table. Care is necessary in fixing that all binding screws are well secured, as the tendency is for the whole to drop when the tube is in position and the lengths are drawn out.

Tube holders to be efficient must necessarily be provided with adjustments to hold the tube in any position. Those constructed to stand on a table are of very limited utility, the pattern resting on the floor being the most serviceable. The holder supplied with a Mackenzie-Davidson's couch may be used for any purpose, as helpless patients can be accommodated on the couch.

CHAPTER III.

Tubes.—When Prof. Roentgen discovered X-rays the tube he used was of quite a different pattern to that which is advertised at the present day. In fact, had not considerable improvements been effected in its construction very little benefit would have accrued to mankind through the discovery. It is earnestly hoped that finality has not yet been reached, so far as further improvements can be effected, as the tube is one of the most important items of the apparatus. In Dr. Jackson's so-called focus tube we have in the arrangement of the anode the initial principle on which the tube of the present day is constructed. It is true that his tube has been improved upon, nevertheless, it must be admitted that the improvements are only modifications of his original theory.

Very briefly, a tube in which X-rays are generated is a glass bulb or sphere, from which the atmosphere to a very great extent has been extracted by means of a mercury air pump. The glass used in the manufacture of tubes is composed of material offering the least resistance to the passage of the rays. It may not be altogether out of place to state in this part of the paper that the transparency of any given substance to X-rays is in inverse ratio to its density; hence it will be understood why ordinary glass is unsuitable, as, containing lead, it would obstruct to some extent the passage of the rays. Into each end of the tube is sealed a piece of platinum wire. Within the tube these wires terminate at different points. To the extremity of one is attached a disc called the anode, which is fixed at an angle of 45° to the axis of the tube. For reasons which will be explained later, most of the tubes now on the market are provided with anodes made of stout aluminium discs faced with platinum. The second wire is secured to a concave piece of metal called the cathode, which faces the anode in the axis of the tube. The distance between the anode and the cathode should be so adjusted that the converging stream of rays from the latter

may not impinge on the surface of the former in absolute focus, a condition which would quickly perforate the disc. If it were possible to obtain a metal sufficiently infusible to withstand the terrific force of the cathodic rays impinging on the anode in absolute focus, improved results would be obtained. The metals osmium and iridium are certainly superior in that respect to platinum, but their great expense is prohibitive, hence platinum, backed by a stout disc of aluminium to absorb the heat, is now generally used in the construction of the anode. In addition to the electrodes, anode and cathode, a third has been introduced, which is now known to act as a steadier of the vacuum. Its position in the tube is behind the anode, and both are connected externally by a piece of wire.

Outside the tube the ends of the platinum wires are attached to metal caps which are cemented to the glass, and to these loops are fixed for attaching the wires from the coil.

A tube suitable for the production of X-rays must have its exhaustion carried to about one-millionth of an atmosphere, and it is therefore obvious that any variation in quantity of the residual molecules of gas will affect the degree of vacuum, hence its management becomes a matter of primary importance. This variation is a weakness common to all kinds, and is experienced in every-day practice. Various automatic regulating devices, having a certain amount of success, have been tried to overcome this weakness, but we are still far from perfection.

As the results obtained by the operator depend in great part on the selection and management of tubes, it will be necessary to go rather fully into these matters.

In selecting tubes the appearance of the source of radiation on the anode should be carefully noted, and this can only be done when they are working. A very small well-rounded red spot on the platinum betokens a tube which will probably give good definition. Should the spot be large and irregularly shaped, or several spots be apparent, the tube should be rejected. This is only a rough and ready means of testing a tube, but may be generally relied on in the absence of a more accurate method.

The penetrating power of a tube, or in other words, the depth of any given substance through which the rays will affect a photographic plate, is estimated by the distance the

secondary current will spark between the discharging points on the coil, in preference to passing through the tube. The distance between the points is termed the alternative spark gap, and its indications are useful in two ways. Firstly, it saves the tubes from probable destruction when the current is too strong, and secondly, by noting the behaviour of certain tubes, as evidenced by the spark gap each requires, a ready means of comparison is afforded when selecting tubes for different services. In the following pages, when the resistance of a tube is expressed in inches, the length of the alternative spark gap is referred to.

Tubes which require a long alternative spark gap to excite them are often spoken of as being "hard," and conversely those requiring a short spark as being "soft." As these terms only convey a general meaning, it is better that the correct resistance should be known, as its length is an important factor in determining the duration of different exposures.

As the tendency of all tubes during use is to increase in resistance, makers, unless otherwise instructed, supply them low, so that they can first be used on easy subjects, such as the hands or feet. It will usually be found that this increase in resistance is fairly rapid, and were it not for the fact that they can be brought down, the active life of a tube would be very brief.

In order to be able to combat to some extent against the variableness in resistance, it is necessary to understand a little about the cause. When a tube is excited, that portion of its inner walls opposite the anode receives a terrific bombardment by gas molecules. In time a portion of these become occluded to the glass, resulting in a diminution of the amount of gas necessary to form a medium by which the current can pass between the electrodes. To bridge this space under attenuated conditions necessitates higher power, and if the increasing resistance is not soon checked the secondary current would find an easier path outside the tube between the terminals. This passage of the current along the outer walls is liable to perforate the glass and ruin the tube.

The remedy at our command to lower the resistance in a tube is to drive the occluded gas back into circulation by the aid of heat. At first it will only be necessary to use a spirit lamp, but in doing so the flame must not be allowed to touch

the glass and soften it to the destruction of the tube. Occasionally it will be found that the resistance increases when making an exposure, and sparks will pass between the discharging points and also along the outside of the tube, in which case the spirit lamp should be provided with a long insulated handle so that heat may be applied without risk of receiving a shock. The use of a spirit lamp has its limits, beyond which it will not affect resistance to any appreciable extent; but fortunately there is another method of applying heat to some purpose before it is found necessary to send the tube to the makers to be re-exhausted. Place the tubes in a gas or other oven for 24 hours with the temperature maintained at about 120° F. On trying them after this treatment it will be found that the resistance has considerably decreased. I have had experience with tubes with resistances amounting to as much as nine inches, which were reduced to two inches in a single night by this method.

For average work the resistance of a tube need only be from four to six inches. If lower it would be suitable for easy subjects, such as the hands, or when skiagraphing the extremities in children.

Having dealt with the methods for lowering resistance, it is now equally important to show how it may be temporarily increased. This can be accomplished by arranging an adjustable spark gap in the secondary circuit. It is a matter of astonishment that this contrivance is not more generally used, as its effect on tubes of low resistance is most marked. It, in addition, eliminates to a considerable extent the back discharge in the secondary circuit, thus making it unidirectional. If used with a coil having a platinum interrupter, it will be found that the platinum points do not so readily fuse as without its use, and the light in the tube will be steadier.

Self-regulating Tubes.—Much commendable energy has been expended by makers and others in the attempt to devise a tube having an automatic arrangement by which the resistance in a tube can be regulated. A certain measure of success has resulted from their efforts, as evidenced by the introduction of the self-regulating tubes. They differ in some respects, but all have the same object in view, namely, the expulsion of gas from a given metal by the aid of heat, either by direct application or by the passage of a current of electricity through

the metal. A full description of the method of using an improved regulating type of Cox's Record Tube is given in one of the appendices to his list, and to those desirous of a more intimate knowledge of the device a perusal of the directions will prove interesting. Personally, I do not think the advance in this direction has gone so far as to supersede the ordinary tube when carefully used. Besides, they are very expensive, and when it is considered that by a little manipulation in the management of the ordinary kind the vacuum can be controlled, as described in detail, to an appreciable extent, a very decided improvement will require to be introduced before the new idea is universally adopted. In one particular, however, their use is commendable, and that is when administering X-ray treatment therapeutically, when every assistance is desirable to keep the tube at a given resistance throughout the exposure. In this respect the self-regulating type supersedes all others.

In estimating the power of a tube for a given object, the appearance of the bones on a fluorescent screen is of great assistance. Should the bones appear grey and only slightly less transparent than the flesh, it indicates that the tube is only fit for screen work, unless worked in connection with a diaphragm. If, however, the bones appear black and only the flesh transparent, the tube is excellent for photographic work.

Adjustable Spark Gap.—This contrivance can be quite easily arranged on any installation, and consists of a means by which a gap may be introduced in one of the wires leading from the coil to the tube. It should be possible to adjust the length of the gap at will, and it may be constructed as follows: Procure a piece of strong glass tubing about 12 inches long, having an internal diameter of about a quarter of an inch. Secure the tubing to the top of a pillar the same height as the coil, and fixed to a firm base. Having previously cut one of the wires at any convenient point, introduce the cut ends into the tubing so that they may meet in the centre. By means of a piece of string firmly secure the wire from the coil to the glass tubing. The wire leading to the tube should be only temporarily secured so that it may be moved at will to regulate the amount of separation between the ends of the wires in the tubing. By separating the ends of the wires the alternative spark gap is increased which has the effect of

raising the intensity of the tube due to the increased E. M. F. introduced into secondary circuit. Although a more elaborate appliance can be obtained, the one described, which has been devised by the writer, has been found to answer all requirements.

Fluorescent Screens.—Were it not for the fact that X-rays possess the power of rendering certain substances fluorescent, their effect would only become apparent on photographic plates. This fluorescent effect enables the eye to see shadows of objects, such as the bones in the hand.

The best screens are coated with barium platino-cyanide, which, being the most sensitive material, gives the brightest light under the influence of the X-rays.

In using a screen the part to be examined is supported between it and the tube. The screen can only be used in a darkened room. In the writer's experience the use of a screen is very limited, and fails to detect such injuries as impacted and sub-periosteal fractures. Preparatory to localising foreign bodies, the use of a screen is of great service in determining the position in which the skiagraph should be taken.

CHAPTER IV.

HAVING in previous chapters explained the component parts comprising an X-ray apparatus, our next consideration is putting them together for actual work. In this procedure it is desirable to act by a preconceived method, and the following is suggested as a guide to the uninitiated. The coil is first prepared by placing the discharging rods in position with the points four inches apart, and if it is intended to use a mercury interruptor, the platinum points on the coil must be separated by a piece of cork or thick cardboard. Turn the handle of the commutator upwards, in which position no current can pass. Test the voltage of the batteries, and make all connections to interrupter and coil as shown in diagrams under the heading of mercury interrupters. Start the motor, afterwards switching the current on to coil by turning down the commutator handle. Observe the sparks passing between the points, and if the interrupter has been properly adjusted they should be rich and thick. For method of adjustment reference is invited to instructions for working mercury interrupters. At one of the points the colour of the discharge will be seen to be of a reddish hue, denoting the positive pole. Carefully note the position of this point as it is connected to the terminal on the anode end of tube. Being satisfied in all these particulars, switch off the current to the coil and stop the motor. Next place a tube in the holder with its axis parallel to the coil, and connect the terminal at the anode end of tube to that on the pillar of the coil carrying the point which showed the reddish discharge. The other terminal on tube and opposite pillar are similarly connected. The wires for making these connections must be well insulated, but need not exceed B.W.G. 25. About an inch of the insulation should first be removed from the ends of these wires and the metal scraped clean. The bare metal ends must be bent round in the form of hooks to make attachment with the terminals. It is usual to form these connecting

LEN WYATT (Stalybridge).

Len. Wyatt has now assisted the Stalybridge Club for seven seasons. He has the reputation of being one of the best and most stylish bats in the Central Lancashire League. Last season he was fourth in the list of all the players in the League, including the professionals, with an average of over 37, and his performances included two centuries against Glossop and Ashton, though the latter was not a League game. Not only does he excel at the summer pastime, but he is also a good football player under Association rules, being a member of the Stalybridge Celtic team.

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48.—Levenshulme: 347 and 365, Barlow Rd.: roomy Houses.

10/6.—65, Heywood-st., M.S.: new range: 5 beds, bath, w.c.

Dwelling-house, with large Store Yard and Sheds: Let or sold cheap. 11 years lease.—Chapman, 44, Broughton Ln.

MOSS SIDE.—69, Derby-street: 2 entertaining, 5 good bedrooms, bath, w.c.: 12s. 6d. weekly.

LONGSIGHT.—Good family House: 432, Surrey Ter.: 5 bed, bath, dining, & drawing rooms: 2 w.c.'s.—Key 434.

TO Let, good House, 45, Bispham-st., Thorp Road, Newton Heath: rent 4/6.—R. Eccles, jun., 41, Corporation-st., City

65 KENDALL-ST., Grey Mare Lane: nice COTTAGES: only good tenants need apply: 4/3

12 SCOTLAND, Rec...k: large Family HOUSE, 7/6. Key at Corner Shop.

CHEADLE HULME.—Good St...t: pleasantly situated: all conveniences: garden.—Apply 86, Gill Bent Road.

GREENHEYS LANE.—Ripon-st.: Grand Houses: 4 beds, 2 enter., bath, &c.: dec.: 9s. & 10s.—Key 74, Denmark Rd.

Old Trafford.—8, Henrietta-st.: d...c'd.: 11/1; Isabella and Walter-st.: splen. Houses: 10/3 & 11/1.-Key greengrocer's.

NO. 94, Bishop-st., Moss Side: 12/6 a week clear: capital Family House: all conveniences.—Key at No. 90.

WEST DIDSBURY.—10, Leopold Avenue: 4 bed, 2 sitting, kitchen, scullery, cellars, bath, &c.: 9s. 6d. c.ear.

Modern House: 4, Hartington-st., Gt. Western-st., Moss Side, adjoin'g Park Bowling Green: nice locality: 10s. w'ly.

HOUSES To Let: Melbourne Terrace, Peru-st., Adelphi, Salford.—Apply Sir James Farmer & Sons, Ltd., Adelphi

WILMSLOW.—House, pleasantly sit'd: 4 sitting & 3 bedrooms: all convs.: £19. 10s.—W. Pickford, Hill Top.

Salford.—36, My-st., Eccles New Rd.: 3 beds, lobbied, w.c.: dec. through: 7/3: key near.—Williams, 64, Corporation-st.

Salford.—10a, Islington-st., Chapel-st.: large clean House: dec. thro': w.c.: ready to go in: 5/6.—Williams, 64, Corp'rat'n-st

Rusholme.—112, Walmer-st.: nice House: dec. thro': w.c.: ...ical to town: 6/3: key near.—Williams, 64, Corporation-st.

LR. Broughton.—31, Melbourne-st.: nr. Co-op. works: 3 beds, bath, w.c.: dec. thro': 7/6: key nr.—Williams, 64, Corporat'n-st.

LR. Broughton.—13, Enid-st., Bury New Rd.: 3 beds, bath, lav., w.c.: dec. thro': 8/-: key nr.—Williams, 64, Corporation-st.

Openshaw.—512, Mill-st.: nice House: dec. thro': w.c.: ready to go in: 5/6: key near.—Williams, 64, Corporation-st.

Blackley.—65, Slack Rd.: 2 large beds: dec. and cleaned through.: w.c.: 4/3: key near.—Williams, 64, Corporation-st.

Hightown.—174, Marlboro' Rd.: 3 beds, bath: dec. thro' and cleaned: 7/-: key near.—Williams, 64, Corporation-street.

Bradford.—19, Sefton-st., Stuart-st.: large House: dec. and cleaned thro': 4/9: key near.—Williams, 64, Corporation-street

HR. Broughton.—40, Wiltshire-st.: 3 beds, bath, lav., w.c.: dec. thro': 9/-: key near.—Williams, 64, Corporation-street.

CHORLTON ROAD.—40, 66, 80, Duke-street: 6-roomed HOUSES: rent 7/6, 7/9: keys 28.—1, Chorlton Road.

GORTON.—5/3 and 5/6: good modern HOUSES: five rooms.—Apply 29, Beyer-street, Church Lane.

6/9—GORTON: Excellent House: will be beautified: every convenience: key at 25, Clay-street, Church Lane.

FALLOWFIELD.—50, Whitby Road: 9/6 clear: 3 bedrooms: bath, w.c.: near tram and train.—Key 28.

NO. 29, Premier-st., Brooks's Bar: Modern HOUSE: 3 bedrooms, 2 parlours, bath, lavatory, and w.c.: 10s. clear.

Manley Park.—27, Cromwell Av.: capital House: 3 good bedrooms, bath, beaut., cleaned: 9s. clr.—Costley, Bridge-st.

PENDLETON.—27, Carlton Rd., off Barrfield Rd.: 6 bedrooms, bath, garden: £28 per ann.: beautified suit tenant

Whalley Range.—88, Manley Rd.: commodious House: 5 bedr'ms, bath: beaut., cleaned: garden: rent reduced 14s. clr.

LONGSIGHT.—No. 4, Richmond Gv. East: capital House: 4 bedrooms, bath, &c.: rent 10/6: key No. 12.

NO. 40, Darnley-st., Brooks's Bar, close to 1d. 'bus: 2 parlours, kitchen, scullery, 3 bedrooms: 10s. clear.

...oss Side.—28 ...hroe-st., Up. Lloyd-st.: lobbied: cel... shed: 6/3.—Ridgway, 72, Market-st.

...: also 2 Furnished Rooms To ...Ridge, Marple.

Levens... cellars

Old Trafford bath: ren

Eccles.—Cap gardens:

UPP. BROO JOHN W

LONGSIGH 9/6.—Un

BROOKLAN rent 5/9

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10/-—Near w.c.:

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wires into helices in order that they may be adapted for any change in position of the tube-holder. The tube, when in position, to be not less than three feet from the coil, as the intense magnetic field set up when the coil is in action might possibly damage it. The motor is now started, and having attained a medium speed, the current is switched on to the coil. Should all the connections have been properly made, half the tube in front of the anode will be seen to glow with an apple green colour, and on using a fluorescent screen, the bones of the hand, for instance, will appear quite distinct. If, however, the connections have been wrongly made, the appearance in the tube will be a series of ill-defined feathery-looking portions of blue light, with no effect on a fluorescent screen. Assuming that the reader has familiarised himself with the management of the tube, an easy subject such as the hand may be skiagraphed, but I propose to do so in a way to show the effects that can be obtained from different exposures.

In the dark room place the photographic plates into double light-tight envelopes in the following manner, so that there can be no doubt regarding the position of the film side of the plate. As there are usually a dozen plates in each box as supplied by the dealers, have ready a like number of both yellow and black envelopes. Arrange these in two lots with the flaps uppermost, and place them side by side on a table in the dark room. Having closed the door of this room and turned on the red light, open the plate box and carefully remove one of the plates. Examine both sides, when it will be seen that one appears dull and lustreless, the other bright and sparkling, when held near the red lamp. The former is the film side, which is always placed next to the part to be skiagraphed. Take one of the yellow envelopes, and turning down the flap place the plate therein film side uppermost. Turn the envelope over and insert it into a black one, so that the film side of the plate is under the plain side of the latter. The remaining plates having been disposed of in like manner, remove them to a place of safety, which must not in any case be in the room where skiagraphs are taken.

To take the skiagraph, the envelope containing the plate is placed on a table at a point convenient to the possible adjustment of the tube-holder. Place the tube in the holder with its axis parallel to and distant from the plate about 20 inches. The hand to be skiagraphed is placed on the envelope, and

by the aid of a plumb line centre the anode over the middle of hand. Procure a piece of sheet lead at least the size of the plate, and place it over the hand in such a way that it completely covers the plate beneath. Now carefully slide the lead along the back of hand until a distance of two inches from the end of plate is left uncovered. Make an exposure of 10 seconds, and taking care that the hand is not shifted from its original position, move the lead another two inches, leaving four inches of the plate uncovered and expose again for 10 seconds. Taking the same precautions as before, move the lead another two inches, and give a similar exposure. Remove the lead altogether and give a final exposure of 10 seconds. The plate on development will show four distinct divisions corresponding to the different exposures received. Fig. 6 is a copy of a skiagraph taken under the conditions as described above. The division marked 4, which was last exposed, and only received 10 seconds, is under-exposed, that is, thin and lacking, in detail. Division 3 received 20 seconds, and although a little stronger than 4, does not equal 2 in fulness of detail, which received 30 seconds. In 1 there is evidence of over-exposure by the loss of contrast. Division 2 would therefore seem to have had the most correct exposure. The same procedure might be adopted with the forearm for a subject, for it is in experiments of this kind that practical experience can be acquired.

One of the primary objects we should aim at in taking skiagraphs is the endeavour to minimise distortion as much as possible, for it must never be forgotten that a skiagraph is simply a shadow of the subject impressed on the plate, and its dimensions are entirely dependent on the distance from the tube. From 20 to 22 inches from anode to plate will generally be found to give the best results. In addition, this distance will assist in protecting the patient from possible X-ray burns. Happily X-ray burning is not common, and cases which have occurred are, in my humble opinion, the result of two causes, viz., low tubes and too near proximity of tube to patient. I have skiagraphed over 3,000 cases and none have suffered in even the slightest degree from X-ray burns, and I think I owe my success in this respect to the attention I always paid to the condition of tubes as well as distance from subject.

In estimating the necessary exposure for a given case there

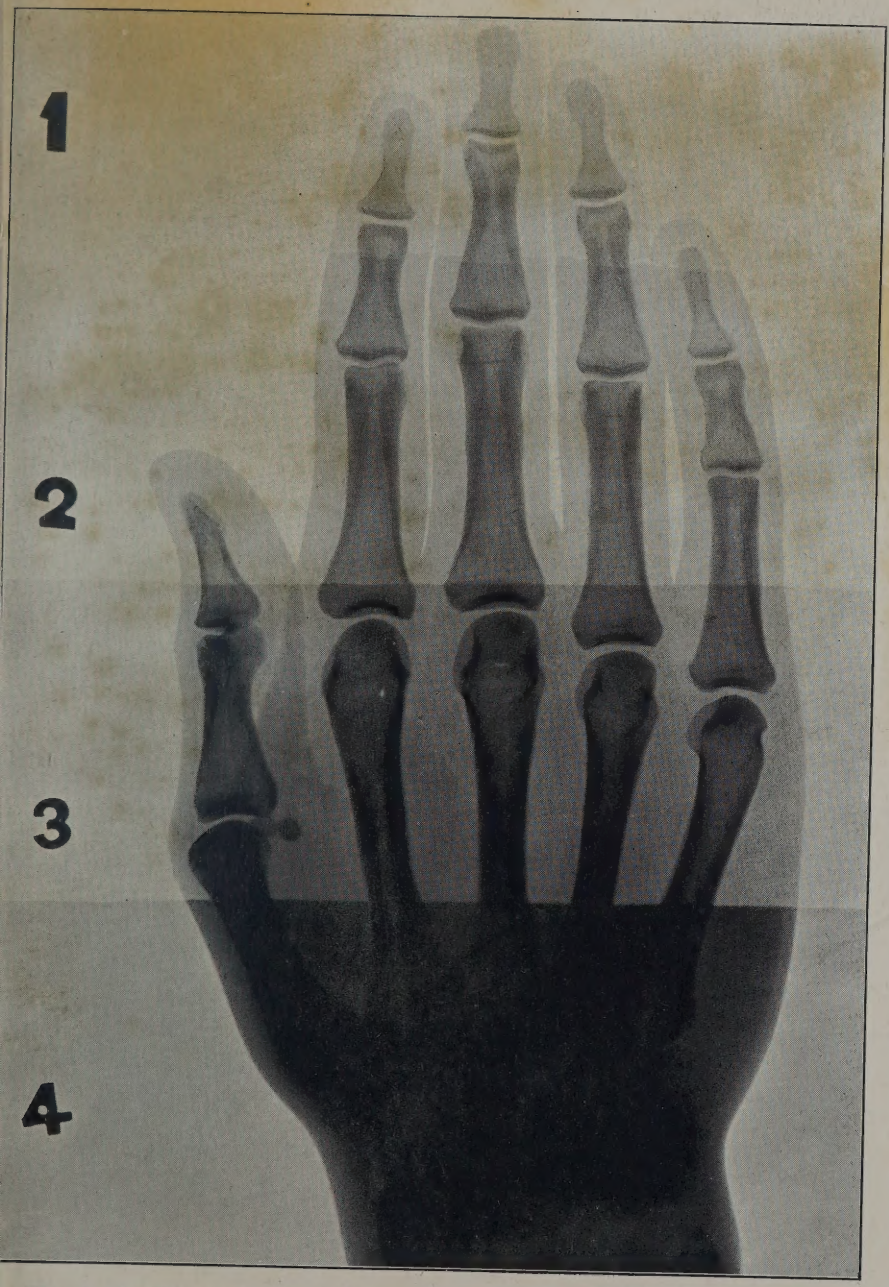


FIG. 6.—To illustrate article by Lieutenant and Quartermaster F. BRUCE, R.A.M.C., "Hints regarding the Management and Use of X-ray Apparatus."

To face p. 32.

are certain factors that must be considered. The part to be skiagraphed may be either the hand or hip-joint as representing extreme conditions, and require totally different exposures. The condition of the tube is very important from the fact that the length of alternative spark gap determines the power of penetration; in other words, the longer the spark gap the shorter the necessary exposure. To produce an image on a photographic plate it must be remembered that the silver salt contained in the film is capable of rendering visible the varying intensities of the light impinging on the plate, no matter whether it proceeds from the sun or an X-ray tube. From this it will be gathered that a very strong light would affect all the silver, producing a result void of all contrast or differentiation. In skiagraphing a thigh, for example, sufficient exposure should only be given to penetrate the soft tissues and at the same time to penetrate the bone to such a degree as to simply show its structure. When tubes of high penetration are used, and unnecessarily long exposures given, hard and soft tissues are penetrated with equal facility, conditions fatal to the production of all contrast. It is therefore obvious that the matter of exposures requires careful consideration. In ordinary photography much assistance is afforded to the operator from exposure tables and light meters. Unfortunately the X-ray worker has no such helps at his command, as no hard-and-fast rule can be laid down for obvious reasons.

For the benefit of the beginner the following exposures are suggested, having given good results in my own experience. But they must be accepted as being approximate only, and should be varied to suit different subjects. The apparatus used was a 10-inch coil operated by a mercury jet interrupter with a primary circuit of 32 volts and 5 ampères. Average condition of tube about five inches alternative spark gap. Hand and foot, 30 seconds; wrist and ankle, 45 seconds; forearm, elbow and lower part of arm, 60 seconds; arm, leg, knee and head, 70 seconds; shoulder and chest, 90 seconds; hip-joint and pelvis, 3 minutes; lumbar region and kidneys, 2½ minutes.

Whenever possible, injuries of the extremities should be skiagraphed in at least two different positions. In the case of fractures a truer estimate of the injury can be obtained from skiagraphs taken from different points than from a

single view which only represents one plane. Where a Wheatstone's stereoscope is available the surgeon is provided with the means by which he can view injuries in relief. Unless this instrument is constructed with appliances for showing negatives as well as prints much time is wasted in preparing the latter, a serious consideration in dull weather. In using this instrument two skiagraphs are taken from two different points, usually a displacement of six centimetres of the tube. To put it more clearly, the second skiagraph is taken after the tube has been displaced six centimetres from the position in which the first was taken. In the absence of a special apparatus for holding the tube, the tube-holder on the Mackenzie-Davidson couch can be utilised, when the cross-bar will form an admirable guide for the travel or displacement of the tube.

Stereoscopic negatives and prints may be very well viewed by the method of converging the eyes, so that the optic axes cross and the right eye sees the left-hand negative and the left eye the right-hand one. This method is easily learned, and is strongly recommended as it renders the surgeon independent of a stereoscope. It is fully described in Stevenson's "Wounds in War," p. 473.

Improved definition can be obtained by using a shield on the tube, when all extraneous rays which tend to fog the plate will be cut off. The rubber shield, as manufactured by Cox, answers this purpose admirably. In skiagraphing the kidneys or lumbar vertebræ the Thurston-Holland compressor diaphragm is of great assistance, and will, I am sure, in time form part of every important X-ray outfit.

CHAPTER V.

Before proceeding to the subject of practical development let us understand, not the theory, but a little about the *rationale* of the process. The light from an X-ray tube in passing through an arm, for instance, meets with varying densities which more or less interrupt its course. The bone tissue checks its passage to a considerable extent, whereas in the softer tissues it meets with comparatively little obstruction on its way to the plate. It is on account of this selective action that we are enabled to obtain an impression of the image formed by the action of light on the silver salt contained in the photographic film. A photographic plate is simply a piece of glass coated on one side with an emulsion containing a silver salt, which is termed the film. This film is extremely sensitive to both artificial and day-light, and must never be exposed to any other than the ruby-coloured light in the dark-room. On examining a plate after exposure to the X-ray, no visible effect will be discerned on the buff-coloured film, and it is only after applying certain chemicals that the effect becomes apparent. These chemicals are termed the developer.

A developer is composed of several ingredients, and these may be classified as follows :—

Developing Agent.—May be either pyrogallic acid, metol or hydrokinone. The action of either of these is to render the latent image visible by the help of the other ingredients. To secure strong, vigorous negatives increase the developing agent; for softer results reduce it.

Accelerator.—Generally the caustics and carbonates of soda and potassium. Its functions are to hasten the action of the developing agent.

Restrainer.—Bromide of potassium is now almost universally used, and its function is to control the too energetic action of the developer. As all developing agents by their nature have a strong affinity for oxygen, it is necessary to protect them

from deterioration by adding a preservative, such as the sulphite of soda, or the metabisulphite of soda or potassium.

A few remarks regarding the behaviour of the different developing agents may be of some little assistance to the beginner when selecting a developer most suitable for X-ray work. The first object in development should be to produce negatives full of contrast, with detail in even the thinnest parts, hence these points must be kept in view when making the selection.

Pyrogallic acid and metol, by gradually acting on the silver salt throughout the film, have been termed "hard-working developers," and consequently build up negatives full of detail but somewhat lacking in density. Hydrokinone, on the other hand, acting energetically on the surface of the film, produces negatives strong in density but comparatively weak in detail. By a compromise these two in combination have been found to give most satisfactory results by thus ncorporating the detail with the density producers. This, at least, has been my experience, and there are many who, to my knowledge, adopt the same method. At the same time, it must be admitted that many operators have produced most satisfactory results by other combinations. Notwithstanding this reservation, I claim for metol and hydrokinone in combination the faculty of being able to produce satisfactory results with a uniformity which makes X-ray work less of an uncertainty in this respect. In the matter of economy metol and hydrokinone, suitably protected by preservatives, can be used again and again until the solution becomes greatly discoloured. Having selected a suitable developer, its functions should be thoroughly mastered, for the greatest percentage of failures have resulted from the eagerness to try all the developers on the market.

The composition of the developer is as follows :—

A.

Metol	1 oz.
Hydrokinone	2 ozs.
Metabisulphite of potassium....	2 „
Bromide of potassium	1 oz.
Water, to	80 ozs.

The metol and hydrokinone must be thoroughly dissolved in hot water before adding the metabisulphite of soda and

bromide of potassium. The solution is then made up to 80 ounces with cold water.

B.

Carbonate of soda	8 ozs.
Sulphite „	8 „
Water, to	80 „

N.B.—The water used in every case should have been previously kept at boiling point for at least 20 minutes to drive off all the free oxygen.

For normal exposures make up the developing solution as follows :—

A	1½ parts.
B	4 „
Water	4½ „

In X-ray practice the uncertainty as to how much exposure any plate has received renders the idea of a standard solution out of the question, and therefore the above solution could only be used for skiagraphs taken of hands and feet when the exposures, by sufficient care, can be made approximately correct. As a precautionary measure all X-ray plates should be developed tentatively by commencing development with half the amount of B, adding the remainder gradually as occasion may require. In giving effect to this principle the following procedure is recommended, and after a little practice its utility will be certain to be appreciated, as forced development is antagonistic to the production of detail in a negative. Having mixed the solution as suggested, using half the quantity of B, place the other half in a glass on a table near to where the plate will be developed in the dark-room. Remove the plate from the double envelope and place it, film upwards, into the developing dish. Holding one corner of the dish with the left hand pour the developer over the plate in such a manner that the surface is covered at one sweep. The dish must now be gently rocked, due care being taken that the wave which is formed by the rocking motion completely covers the film, otherwise the film will be marked, as a result of unequal development. The dish should be held some distance from the lamp, as even the ruby-coloured light might cause fogging of the film. This precaution is most necessary, for a perfect non-actinic light has not up to the present been devised which will effectually protect during

development the extremely sensitive emulsions used in the preparation of X-ray plates. Now carefully watch the surface of the film for the appearance of the object skiagraphed. If after rocking a minute nothing appears, add one more ounce of B to the solution which has been previously returned to the measure glass. On no account must additions be made to a developer whilst it is in contact with the plate. If the exposure had been anything like correct the addition should bring up the object. Presuming that this is so, continue rocking for five minutes with the view of bringing up detail and add another ounce of B to complete the development. The question of how far a plate should be developed is an extremely difficult one to answer. Using Edwards' Cathodal plates the image should be developed through so that it can be seen distinctly on the glass side of the plate. With a Lumiere plate the appearance on the glass side should be a fairly distinct view of the object and the other parts discoloured. It must always be borne in mind that the end in view when making negatives is the production of prints, hence the density or light-stopping properties in a negative determines how far they shall be successful. With a thin, ghostly-looking negative it is impossible to obtain prints of any excellence. On the other hand, a negative full of detail with strong contrasts and fairly opaque in the darker portions will give a satisfactory reproduction on paper. Of course, a very thin plate can be intensified, and conversely, a very dense one reduced, but of the two evils choose the latter, which is the more easily corrected. Intensification is an exceedingly difficult operation, and rarely succeeds unless in skilled hands. For these reasons I strongly suggest that one should err on the side of over- rather than under-development. The two processes will be explained under another heading. Having decided when to stop development, the plate is removed from the dish and given a fairly good wash under a tap. It is then placed in a solution called the fixing bath, consisting of hyposulphite of soda 6 ounces, bisulphite of soda 1 ounce, and water to make 1 pint. The object of the fixing bath is to remove all the silver from the film which has not been acted upon during the period of exposure and subsequently by the developer. Fixation is complete 10 minutes after all white-coloured portions have disappeared from the back or glass side of the plate. This will ensure thorough fixing, for

it is more often through carelessness in this respect that the permanency of a negative is affected than from faulty washing. Daylight can now be admitted into the dark-room, as all sensitive matter has been removed from the film by fixing. It now remains to wash the negative to free it from all traces of hyposulphite of soda, which seem to stick to the film like barnacles to the bottom of a ship. To do so efficiently the plate, held vertically by a rack, is placed in a tank under a tap, and the water allowed to run for at least two hours. When the soda is dissolved out of the film it sinks and collects at the bottom of the tank, and unless means are taken to drain away the waste water from the bottom the lower part of the plate will be insufficiently washed. A tank having a syphon answers the purpose admirably, provided a small hole is made in the upper bend of the pipe to keep the water at one level. In hot weather, when there is a tendency for the gelatine to become soft and blister, wash the plate for a few minutes after fixing and then immerse it in a solution of alum, two ounces to the pint of water, allowing it to soak for five minutes before returning it to the washing tank. In tropical climates it is advisable to use a 5 per cent. solution of formaldehyde, which is more powerful than the alum. Immediately before finally removing the plate from the tank, swab the surface of the film under the level of the water by a piece of cotton-wool, to remove all traces of grit or other matter. The plate must now be placed vertically in a rack to dry, and on no account must this be forced, by placing it near a fire, for instance.

Failures in the photographic part of X-ray work are more numerous than in the electrical department. To the beginner a failure should be the means of imparting a never-to-be-forgotten lesson; for why so many people have come to grief is simply because shortcomings have never been reasoned out and accounted for, and they blunder on, trusting to chance eventually clearing matters up—a vain hope. The futility of such happy-go-lucky methods is obvious, and emphasizes the fact that to obtain good results the whole procedure must be reasoned out step by step. To assist the novice in correcting his failures a few of the more frequent pitfalls are given, but after a little care and practice recourse to the remedies will seldom be necessary.

Blistering.—This is due, as previously stated, to the gelatine

softening by reason of the developing solution being too warm. To provide against this the temperature of the solution and the washing water should never exceed 65° F. It is a good plan to harden the film soon after fixing, either by alum or formaldehyde. If, however, the film shows signs of evident blistering a hardening medium will not eradicate the evil thus formed. In such cases immerse the plate in methylated spirits for a short time, and after a slight wash place it in a hardening bath. In the Tropics a few drops of 5 per cent. solution of formaldehyde added to the developer will assist in rendering the gelatine insoluble.

Negative too Dense.—This condition is easily corrected by using the Howard Farmer reducer. The formula is :—

A.

Ferricyanide of potassium	20 grains.
Water	1 oz.

B.

Hyposulphite of soda	1 oz.
Water	20 ozs.

Take enough of B to cover the plate when laid in a dish, and add a few drops of A. The action of this reducer is very energetic, and must be watched very carefully. When the plate has been sufficiently reduced, at once remove it from the solution and wash thoroughly. The solution will not keep and should be thrown away.

Negative too Thin, with Little Contrast.—This condition is generally due to either under-exposure or under-development. To make such a negative presentable it must be intensified by some method to increase the contrasts. To carry out this process successfully the film must be thoroughly cleared of all hyposulphite of soda, stains and fog. A slight application of the Howard Farmer reducer will effect the latter, but the washing must be thorough, as the slightest trace of soda present in the film would mar the results.

Prepare the solutions as follows :—

A.

Perchloride of mercury....	300 grains.
Hydrochloric acid	30 drops.
Water	10 ozs.

B.

Liquor ammonia (0·880)	20 drops.
Water	1 oz.

Place the negative, wet, in a dish, and pour A over the film, taking care that it is completely immersed. The surface will be seen to slowly turn a whitish colour, but it is the appearance on the back which must be watched. If the negative under treatment be very thin, then the film must be bleached right through, so that the back appears almost white. On the other hand, when only slight intensification is necessary, the bleaching need not be carried quite so far. In any case, after bleaching, the plate must be returned to the washing tank and the water allowed to run for at least half an hour. Again placing it in the dish, B is poured over the film and the former gently rocked. The effect of the ammonia solution is to redevelop or darken the film, and should be continued until the back appears as black as the front. A thorough washing for about half an hour completes the process. A negative can be intensified either before or after it is dry; if the latter, it must first be thoroughly soaked in water for half an hour.

Under-exposure.—Plates which have not received sufficient exposure develop very slowly; parts, in fact, refusing to darken at all. Under these circumstances it is best to dilute the developer in order to coax out all possible detail. Whenever possible it is preferable to make another exposure, as trying to doctor an underexposed negative is both tedious and uncertain.

Over-exposure.—A plate which has received an excessive exposure flashes up immediately the developer is flowed over the film. The remedy for such is to increase the developing agent and to decrease the accelerator. Development should be carried to the fullest extent, and over-density can afterwards be corrected by recourse to the Howard Farmer reducer. A well-known maxim is to err rather on the side of over- than under-exposure.

Before passing to the subject of printing from the negatives, a few remarks regarding the selection of photographic plates may not be out of place. There are many brands of plates in the market, all excellent in their way for ordinary photographic work.

In selecting a plate for X-ray work the chief desiderata are that it should be rich in silver to facilitate the production of a skiagraph with strong contrasts forming the image, and permitting of great latitude in exposure, the last a most

valuable consideration. Using such a plate, and with ordinary care, the most perfect results can be obtained with the minimum of trouble. Skiagraphs are in the majority of cases valuable records, a fact which must not be lost sight of when choosing plates.

Printing from the Negatives.—The most simple method, which will give the best results, is obtained by the use of the ordinary printing out paper, usually known as P.O.P. Personally I use the Ilford brand, but there are others quite as good. The procedure is as follows :—

The negative, which must be thoroughly dry, is placed in the printing frame and a piece of P.O.P. laid on the top with the film or glossy side against the film side of the plate. Before putting on the cover put a piece of clean blotting paper over the P.O.P. to assist in keeping it close to the plate. Carefully clean the glass side of the plate, and set the frame on end facing the light. Avoid printing in direct sunlight, as it is liable to cause mealiness in the prints. Strong diffused light is preferable. Examine the print occasionally in a dim light to note progress of the printing. Only one end of the cover must be opened at a time. When the darker portions have become slightly bronzed it may be taken for granted that the print is finished. Of course, it must be understood that the effect must be carried farther than what will appear on the finished print, as a good deal of it is lost during the toning and fixing processes. Having finished printing, say, eight pieces, 8½ by 6½ inches, arrangements may now be made for finishing them. I should mention that as each print is removed from the frame it must be placed in some receptacle to shield it from the action of the light.

Prepare the following stock solutions :—

A.

Sulphocyanide of ammonium	2 ozs.
Water, to	16 ,,

B.

Chloride of gold (1 tube)	15 grains.
Water, to	15 drams.

The toning bath is made up as follows :—

A	½ oz.
B	2 drams.
Water	1 pint.

Carefully filter to remove all impurities. This quantity will suffice to tone eight pieces of P.O.P., each measuring 8½ by 6½ inches.

The prints are put singly into running water and kept moving about until all milkiness in the water has disappeared. This preliminary washing usually occupies about 15 minutes. The dish in which the prints are to be toned must be very carefully cleaned before the solution is emptied into it; and note that this dish must not be used for any other purpose. Taking four prints from the washing water, immerse them one at a time in the toning bath and keep them moving about to prevent the surfaces sticking together to cause uneven toning. Toning may be said to be complete when, on looking through the prints, the reddish-brown colour has disappeared from all but the darkest portions, and the surface shows a uniform purplish hue. As soon as each is toned it is returned to the washing tank and the whole well washed for at least 10 minutes. The fixing bath may now be taken in hand and is prepared by dissolving 4 ounces of hyposulphite of soda in 1 pint of water. It is very essential that toning and fixing be regarded as two distinct operations, as the slightest trace of soda would ruin the toning bath, causing indelible stains on the prints. A safe rule is to finish toning before doing anything at all with the fixing bath. Attention to this rule will save endless disappointment. Fixing is complete in 15 minutes. As when toning, the prints must be kept moving about to permit equal fixing. The fixed prints are now washed for 10 minutes and afterwards immersed in a hardening solution of alum, 2 ounces to the pint of water, to prepare them for the polishing process. The final washing needs careful attention in order to thoroughly eliminate the soda. Two hours in running water will be sufficient, provided the prints are kept moving about and not allowed to collect in a a mass on the bottom of the tank.

Polishing the Prints.—The appearance of the finished print is greatly enhanced by a polished surface, so easily accomplished by using P.O.P. Procure some very clean pieces of glass, useless negatives which have been well cleaned are quite suitable, and polish one side with methylated spirit and a clean piece of chamois leather. Next dust a small quantity of French chalk on to the clean surface and rub it well in with a fresh piece of chamois leather, afterwards holding the plate

under the tap to remove any loose portions of chalk. Be careful not to touch the polished surface with the fingers so as to leave a greasy mark. Lay the plate flat down on a piece of blotting paper, and taking one of the wet prints place it on the glass, film side against the polished surface. Using a roller squeegee carefully press the print on to the glass, working the squeegee to and fro several times to give proper contact. Remove the surface water by means of a piece of blotting paper and the use of the squeegee. Stand the glass up in an even temperature, never near a fire, and allow the print to gradually dry, when it will peel off. On no account must the drying process be hastened, as the gelatine will soften and stick to the glass. Neither must the prints be touched until thoroughly dry or attempts be made to force them off the glass. In order to make the polishing process permanent the prints must be backed by pasting drawing paper on the backs when the paper feels dry to the touch. This somewhat retards the drying process, but the extra trouble is well repaid by the extra finish and permanency of the prints. When prints stick to the glass the cause is most generally the want of proper care in preparing the glass supports. It has been stated that ferrotype forms a better support than glass, but my experience cannot bear this out.

CHAPTER VI.

Mackenzie-Davidson's Localising Apparatus.—It is a well-known fact that where foreign bodies are embedded in deep tissue their location as shown on X-ray photographs is altogether illusory. The position of the foreign body, as seen on the plate, is entirely dependent on the direction of the rays; it is therefore possible by the adjustment of the anode to make the body appear as being situated far from its true position. Before the advent of the localising apparatus many mistakes were made through the non-appreciation of that fact, with the result that X-rays were held up to derision. However, this unsatisfactory state of matters suddenly ceased when it became possible to locate to a millimetre such articles as needles in any part of the human body. Mr. Mackenzie-Davidson, in his original article on the subject, which appeared in the *British Medical Journal* on January 1st, 1898, states as follows: "It is not enough for the surgeon to have a fine photograph or a skiagraph of the part of the human frame showing the presence of a foreign body. He wants more than that to enable him to operate with complete confidence. He wishes to know the size of an object and its position and depth from the skin at any point he may select. The extended use of the X-rays has led to an increasing need for some simple method of localisation which can be at once readily carried out, and at the same time be reliable. The method I have devised I believe is of this character, and I have had an apparatus constructed which fulfils these requirements. It was, of course, obvious from the first that taking a skiagraph from two or more points of view was the necessary starting point to any method of localisation. But the question was, how the resulting photographs were to be dealt with to give the desired information as to the precise position of this foreign body. This remained a difficulty, except to the comparatively few who were sufficiently familiar with geometrical drawing and mathematics."

The apparatus consists of a couch having two uprights for carrying a horizontal bar, from which the tube is fixed by means of a holder. The top of the couch is divided into five movable parts, to one of which are fixed the upright bars and also

the receptacle for holding the plate during the exposures. This receptacle is in the form of a shallow box, with a tightly-stretched skin, drum-like cover, over which two wires are arranged at right angles to divide it into four equal parts. The under part is in the form of a trap door to permit of the plate being placed in position below the wires, so that they will show on the skiagraph. The part to be taken is placed over the wires after the tube has been adjusted. The other part of the apparatus consists of a contrivance for reproducing the rays by means of threads when making the necessary calculations from the appearances on the negative.

The procedure in arranging the apparatus, taking the skiagraph and making the calculations, is as follows :—

Adjust the anode of the tube so that its centre is coincident with the intersection of the wires on drum. This can easily be done by the aid of two plummets having cords of equal length. Attach a hook to the free end of each cord for the purpose of suspending the plummets from the loops at the extreme ends of the tube, the latter having previously been placed in position in the holder with its axis parallel to the plate holder. By means of the holder, adjust the position of the tube so that the plummets hang directly over the wire situated at right angles to the couch. Standing at the end of the table, and by the aid of a plumb-line, carefully bring line, centre wire and anode into one line by moving the tube-holder. When making this adjustment, the plumb-line should be held at the full extent of the arm, and at least three feet from the end of the table. The height of the centre of anode from plate must now be ascertained. Personally I use the plumb-lines which were suspended from the ends of the tube to arrive at this measurement by making them of a given length, usually about 20 inches, and as the centre of anode is situated in the axis of the tube the distance thus obtained must be approximately correct. The position of the tube-holder, as indicated on the scale on the horizontal bar, should be noted. A stop is now fixed three centimetres from either side, when the tube-holder can be drawn aside to permit of the patient being placed on the table without risk of deranging the adjustment of the tube.

Having decided on the part which is to rest on the plate, the latter is placed in position under the cross wires and the trap-door firmly secured. It is usual to make a screen examination to find out approximately the position of the

foreign body, so that the part in which it is situated may be conveniently placed on the drum. A small coin is placed on one of the quadrants and a mark made on the skin immediately above it. The tube-holder is now brought close up to the fixed stop and secured. The centre of anode is thus three centimetres from the central adjustment. The first exposure is then made, and the patient warned not to move. Move the tube-holder along the bar six centimetres, secure, and make second exposure. Note that the anode was three centimetres on other side of central adjustment when the last exposure was made.

On the patient being removed from the drum it will be found that the skin bears the imprints of the wires. With a piece of nitrate of silver mark the skin at the extremities of the imprints, also the part which lay in the same quadrant as the coin. Nitrate of silver is recommended, because, during the process of preparing the part for operation, ink or other marks would be obliterated, in which case another localisation would be rendered necessary. Before taking parts such as the palm of the hand, which would not show imprints of the wires, smear the latter with a good quantity of ink, such as is used for rubber stamps, not neglecting to use nitrate of silver in the same manner as before described.

Develop, fix and wash the plate; and should immediate localisation be required immerse the plate in a formalin bath, when it can be quickly dried.

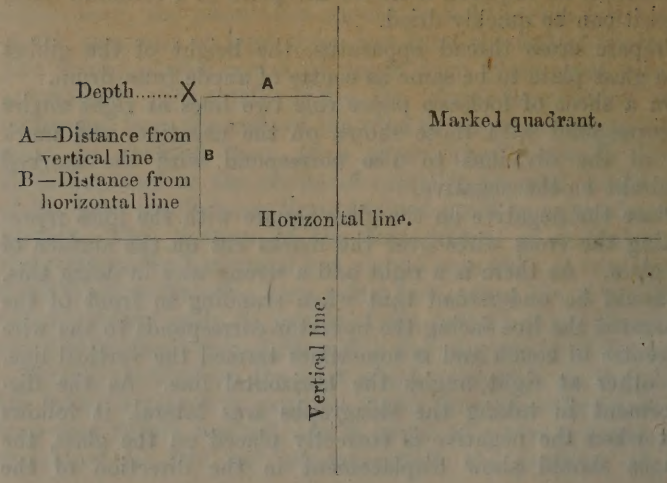
Prepare cross thread apparatus, the height of the gibbet from glass plate to be same as centre of anode from drum.

On a sheet of foolscap paper rule two lines at right angles to correspond with those shown on the negative, and mark one of the divisions to also correspond with the marked quadrant on the negative.

Place the negative on the glass square with the lines representing the cross wires over the marks cut on the surface of the glass. As there is a right and a wrong way in doing this, it should be understood that when standing in front of the apparatus the line facing the operator corresponds to the wire on centre of couch and is sometimes termed the vertical line, the other at right angles the horizontal line. As the displacement in taking the skiagraphs was lateral, it follows that when the negative is correctly placed on the glass, the images should show displacement in the direction of the

horizontal line. Lower the mirror until the negative is brightly illuminated. Next take one of the metal weights, to which a needle is attached by a screw. A piece of silk thread is secured to the body of the weight and the other end passed through the eye of the needle. Conduct the thread through one of the slits in the gibbet and over the pulley at the same side of the standard and fix the counterweight. The other weight and thread is arranged in like manner over the opposite slit and pulley. The slits are six centimetres apart, hence care must be taken that the displacement of the tube should not exceed that distance. Cross the threads and place the eyes of the needles one on each of the two images.

By means of the surface gauge the height from plate to intersection of the cross threads is ascertained. This height represents the distance the foreign body is under the skin, and should be carefully noted down. Next measure the distances between the point where the threads cross and the vertical planes of the vertical and horizontal lines. Place the upright square, with its lower edge coincident with the vertical line, and by the aid of a pair of compasses measure the distance between the intersection of the threads and square. Next place the upright square against the horizontal line, and measure off the distance from the cross threads in the same way as from the vertical line. These measurements should be carefully noted down and a diagram prepared as follows :—



Before attempting to localise a foreign body in any part of the human frame, it is strongly recommended that a few experiments be made on needles embedded in turnips or in loaves of bread, in order that the procedure may be fully understood. The absence of the most careful attention to detail may cause the surgeon to operate in a wrong quadrant. As a preliminary before the operation I invariably place the negative over the part, film downwards, in order to prove position of marked quadrants.

As regards the question whether it is necessary to use a fresh plate for each exposure, much will depend on circumstances. For the extremities, the two exposures can be made on one plate without suffering any inconvenience from fogging. Many operators invariably use two plates, but this I have never found to be absolutely necessary except when localising needles in deep tissue. In South Africa I never used more than one plate for bullets situated in any part of the body.

APPENDIX.

Developer for X-Ray Plates.

The following developer has been used for some years at the Royal Army Medical College, and gives good results :—

No 1.

Hydrokinone	640 grains.
Sodium sulphite	8 ozs.
Citric acid	240 grains.
Potassium bromide	80 „
Distilled water, to	80 ozs.

No. 2.

Sodium carbonate	8 ozs.
Potassium carbonate	8 „
Distilled water, to	80 „

For normal exposures take equal parts of each.

Developer for use in hot climates.

Hydrokinone	160 grains.
Sodium sulphite	3 ozs.
Potassium bromide	5 grains.
Formalin	240 minims.
Distilled water, to	20 ozs.

This formula works well at a temperature of 85° F., it prevents frilling, and gives dense negatives. The formalin acts as the accelerator, taking the place of an alkali.

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